

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Appellant: Karen M. CHEVES et al. Confirmation No.: 5388
Serial No.: 10/828,699 Examiner: Andrew M. Gilbert
Filing Date: April 21, 2004 Group Art Unit: 3767
Docket No.: 1001.1705101 Customer No.: 11050
Title: TRACTION CUTTING BALLOON

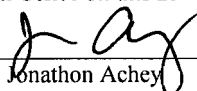
APPEAL BRIEF FILED UNDER C.F.R. 37 § 41.73

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By _____


Jonathon Achey

Dear Sirs:

Pursuant to 37 C.F.R. § 41.37, Appellant hereby submits this Appeal Brief in furtherance of the Notice of Appeal filed on December 8, 2010, and of the Notice of Panel Decision from Pre-Appeal Review mailed January 26, 2011. Appellant authorizes the fee prescribed by 37 C.F.R. § 41.20(b)(2) in the amount of \$540 to be charged to Deposit Account No. 50-0413. Permission is hereby granted to charge or credit Deposit Account No. 50-0413 for any errors in fee calculation.

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I. REAL PARTY IN INTEREST

The real party in interest is the assignee of record, Boston Scientific SciMed, Inc., having a business address of One SciMed Place, Maple Grove, Minnesota 55311-1566. An assignment from the inventors, Karen M. Cheves, Loren M. Crow, Gregory S. Kelley, Steven A. McAuley, Herbert R. Radisch, Jr., Ricardo David Roman and Show-Mean Wu, conveying all right, title and interest in the invention to SciMed Life Systems, Inc. has been recorded at Reel 015620, Frame 0197, with a subsequent change of name to Boston Scientific SciMed, Inc., recorded at Reel 018505, Frame 0868.

II. RELATED APPEALS AND INTERFERENCES

There are no other known appeals or interferences that will directly affect, or be directly affected by, or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 15 and 26-33 are pending in the application. Claims 1-14, 16-25 and 34 have been canceled from the application.

Claim 15 and 26-33 stand finally rejected under 35 U.S.C. § 102(e) as being anticipated by Wu et al. in U.S. Patent Application Publication No. 2004/0243156.

Claims 15 and 26-33 of the application are currently being appealed.

IV. STATUS OF AMENDMENTS

An Amendment after the final rejection of September 8, 2010 was filed on November 8, 2010. The Advisory Action mailed on November 23, 2010 indicates that for the purposes of Appeal, the Amendment After Final of November 8, 2010 was entered into the record.

V. SUMMARY OF CLAIMED SUBJECT MATTER*

The present invention pertains to angioplasty and angioplasty balloon catheters. More particularly, the present invention pertains to angioplasty balloon catheters that include one or more cutting edges coupled to the angioplasty balloon.

Turning now to independent claim 15, which is directed to a cutting balloon catheter (see, for example, page 3, lines 5-6; Fig. 1, element numeral 10), comprising: an elongate catheter shaft (see, for example, page 3, lines 6-7; Fig. 1; reference numeral 18); a balloon (see, for example, page 3, lines 6-7; Fig. 1; reference numeral 16) coupled to the shaft, the balloon having a first fully inflated configuration (see, for example, page 3, lines 9-10; Fig. 1; reference numeral 16) and a second non-inflated configuration (see, for example, page 9, lines 8-9; Fig. 2; reference numeral 16), wherein the balloon has a plurality of substantially smooth wings (see, for example, page 9, lines 8-9; Fig. 2; reference numeral 36) formed therein when in the second non-inflated configuration; a metallic cutting blade (see, for example, page 3, lines 7-8; Figs. 1 and 2; reference numeral 20) for severing or breaking up a lesion adhesively bonded to the balloon (see, for example, page 13, lines 1-3) throughout the entire use of the cutting balloon catheter (see, for example, Figs 1 and 2; reference numeral 20 bonded to reference numeral 10 in both fully inflated and non-inflated configurations), the cutting blade including means for cutting having two intersecting planes which form a cutting edge (see, for example, page 11, lines 3-6; Fig. 4; reference numeral 220), including means for gripping (see, for example, page 11, lines 6-9; Fig. 4; reference numeral 223) thereon, having a longitudinal axis, and having a cross-sectional shape that is substantially triangular in a plane transverse to the longitudinal axis (see, for example, Figs. 3-5); wherein the means for cutting and means for gripping are defined by a series of undulations (see, for example, page 11, lines 3-5; Fig. 4) on the cutting blade in the first fully inflated configuration; and wherein the undulations curve from side-to-side (see, for example, page 11, lines 3-6; Fig. 4; reference numeral 220) relative to the longitudinal axis in the first fully inflated configuration.

* The references to the specification and drawings provided herein are exemplary, and are not deemed to be limiting as support may be found throughout the specification and in many of the Figures.

VI. GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Whether claims 15 and 26-33 are anticipated under 35 U.S.C. § 102(e) over Wu et al. in U.S. Patent Application Publication No. 2004/0243156.

VII. ARGUMENT

A. CLAIMS 15 AND 26-33 ARE PATENTABLE UNDER 35 U.S.C. §102(e) OVER WU ET AL. IN U.S. PATENT APPLICATION PUBLICATION NO. 2004/0243156.

- 1. A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.*

The Final Office Action indicates that claim 15 is rejected under 35 U.S.C. §102(e) as being anticipated by Wu et al., U.S. Pat. App. Pub. No. 2004/0243156. Furthermore, the Final Office Action indicates that claims 15 and 26-33 are rejected under 35 U.S.C. §102(e) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Wu et al., U.S. Pat. App. Pub. No. 2004/0243156. Appellants note that the rejection under 35 U.S.C. §103(a) has been withdrawn in the Advisory Action in view of Appellants' showing of common ownership between Wu et al. and the current application at the time of the invention under the provisions of 35 U.S.C. §103(c), leaving only the rejections of claims 15 and 26-33 under 35 U.S.C. §102(e). Appellants respectfully traverse this rejection.

Claim 15, among other limitations, recites, "wherein the means for cutting and means for gripping are defined by a series of undulations on the cutting blade in the first fully inflated configuration." In the Final Office Action, it was indicated that "Wu is silent regarding any undulations of the blades when the balloon is inflated." See Final Office Action of September 8, 2010, at paragraph 7.

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." M.P.E.P. §2131, quoting *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631 (Fed. Cir. 1987). The admission in the Final Office Action that Wu et al. does not teach undulations of the blades when the balloon is inflated evidences that the §102(e) rejection

of the currently pending claims is inappropriate. Appellants assert that Wu does not explicitly, impliedly or inherently disclose these limitations.

Wu shows the wings and blades appearing to have side-to-side undulations when the balloon is in its deflated state. For instance, Wu discloses (last 8 lines of paragraph 0036, emphasis added):

Generally, the use of apparatus 46 results in the alteration of the geometry of balloon 14 so that a generally repeatable deflation shape is formed in the balloon material so that wings 42 are formed and visible when balloon 14 is deflated. It is believed that the disclosed balloon geometry, that may include a plurality of wings 42 having undulations 44, helps render the balloon more foldable, more re-foldable, and more collapsible.

Regarding side-to-side undulations when the balloon is in its fully inflated state, Wu appears to show that the undulations of the wings disappear when the balloon is inflated. Fig. 3 of Wu shows the undulations 44 of the wings 42, when the balloon is deflated, while Fig. 4 of Wu clearly shows an absence of those undulations when the balloon is inflated. Namely, Wu states, “When balloon 14 is inflated, wings 42 may become expanded and, thus, not visible as illustrated in FIG. 4.” Wu, at paragraph 0034.

In Wu, while the undulations of the wings clearly disappear when the balloon is inflated, Wu is silent regarding any undulations of the blades when the balloon is inflated. Appellants note that it is likely that in the inflated state, the cutting members would extend longitudinally along a straight path, without any undulation, as there would be no wings 42, and thus no undulating surface 44 that the cutting members would match.

In maintaining the rejection, Examiner responded to Appellants’ argument, stating that “The cutting members are made of a cutting structure, such as a metallic cutting blade similar to a knife, that has a rigid structure ([0018]). There is no expectation that the undulations in the cutting member will change between first and second configurations because a metallic cutting blade similar to a knife will maintain its shape due to its material composition, which is far different from the material composition of the balloon ([0020]).” See Office Action of June 2, 2010, at paragraph 8.

Appellants respectfully disagree. Appellants assert that in the Examiner’s response to the Appellants’ presented argument, the Examiner appears to rely on “expectation” of the rigidity of Wu’s blade to conclude that the undulations would remain

when the balloon is inflated. Appellants respectfully disagree with this reliance on rigidity. For example, U.S. Pat. Pub. 2005/0228343 to Kelly (“Kelly”) describes a cutting balloon catheter and method for mounting a cutting blade on a balloon. Kelly states, “Cutting members 20 may be made from any suitable material such as a metal, metal alloy, polymer, metal-polymer composite, and the like, or any other suitable material.” Kelly at paragraph 0013. Kelly describes an arrangement of mounting the cutting blades 20 onto the balloon 16 using a joining member 38 between the cutting blade 20 and the balloon 16. Kelly, at paragraph 0022, states:

In some embodiments, joining member 38 may be formed from a generally flexible or soft material that allows the interface or connection between the cutting member 20 and balloon 16 to be secure while also being, in some embodiments, somewhat elastic or pliable. For example, joining member 38 may be manufactured from a low durometer polyurethane or any other suitable material (including any of the polymers and other materials disclosed herein). Accordingly, cutting member 20 may be securely coupled to balloon 16 while still being able to move laterally about eight degrees or less. Additionally, different portions of cutting member 20 may be able to bend or flex, while other portions remain essentially unchanged. In other embodiments, joining member 38 may be formed from a somewhat harder material.

Thus, Kelly teaches that metal cutting blades, while mounted to the balloon, may be able to bend or flex. Such bending or flexing may facilitate navigating the cutting balloon catheter through the vasculature to a stenosis or lesion.

Appellants further assert that because Wu appears to be silent regarding the undulations of the blades when the balloon is inflated, and because the Examiner appears to rely on blade rigidity to determine if the undulations would disappear or remain when the balloon of Wu is inflated, then it appears that the Examiner is relying on an inherency argument to show that Wu anticipates that the blade undulations remain when the balloon is inflated. Appellants respectfully disagree with this inherency argument.

The MPEP states in Section 2112, subsection IV, paragraph 2:

"In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art." *Ex parte Levy*, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990) (emphasis in original)

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Appellants assert that even though the blade disclosed by Wu may be formed from metal, the blade does not necessarily possess the rigidity to ensure that the undulations of the blade would remain when the balloon is inflated. As taught in Kelly, cutting blades formed of metal may be able to bend and flex while mounted to the balloon. Thus, if constructed as taught in Kelly, the undulations of the cutting blades of Wu in the deflated state may likely disappear in the inflated state such that the cutting members would extend longitudinally along a straight path, without any undulation, as there would be no wings 42, and thus no undulating surface 44 that the cutting members would match. As such, Appellants assert that maintaining the undulations of Wu's blade when the balloon is inflated is not an inherent property of Wu's blade.

As a result, Appellants assert that Wu does not expressly, impliedly or inherently disclose "wherein the means for cutting and means for gripping are defined by a series of undulations on the cutting blade in the first fully inflated configuration" and "wherein the undulations curve from side-to-side relative to the longitudinal axis in the first fully inflated configuration", as recited by claim 15. Appellants assert that claim 15 is not anticipated by Wu.

Furthermore, in responding the Appellant's previously presented remarks regarding the teachings of Kelly, U.S. Pat. App. Pub. No. 2005/0228343, it was stated in the Final Office Action that "One of ordinary skill in the art at the time of the invention would have found it obvious that a metallic cutting blade that is similar to knife would hold its structural configuration as the balloon transitions from an deflated to fully inflated configuration, thus maintaining the undulations in the fully inflated state." Final Office Action, at paragraph 8. While Appellants do not agree with this assertion, it appears that this argument presented in the Final Office Action is formulated under the provisions of 35 U.S.C. §103(a).

As noted above, even though the blade disclosed by Wu et al. may be formed from metal, the blade does not necessarily possess the rigidity to ensure that the undulations of the blade would remain when the balloon is inflated. For example, as noted previously the cutting blades disclosed in Kelly may be able to bend and flex while mounted to the balloon. See Kelly, at paragraph 0022. Kelly, which teaches the cutting blades may be formed of any suitable material such as a metal, metal alloy, or polymer,

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does not distinguish between these materials or indicate metal materials would not permit the described bending or flexing of the cutting blade when mounted to the balloon, concluding that any disclosed material, including metal, would permit the disclosed bending or flexing of the cutting blade while mounted to the balloon. In consideration of the size of such a cutting blade (e.g., on the order of 0.006 inches wide) a metal material would not necessarily be sufficiently rigid to prevent bending or flexing of the cutting blade. Furthermore, the inclusion of the joining member 38 of Kelly does not negate such a conclusion. The blade itself would need to be able to bend and flex, as described, regardless of the presence of the joining member 38 since the presence of the joining member 38 would not make an otherwise rigid blade become flexible. As such, Appellants assert that maintaining the undulations of Wu's blade when the balloon is inflated is not an inherent property of Wu's blade.

As a result, Appellants assert that Wu et al. at least does not expressly, impliedly or inherently disclose the noted limitations of claim 15. Withdrawal of the §102(e) rejections of the claims is respectfully requested.

2. *If an independent claim is not anticipated under 35 U.S.C. §102, then any claim depending therefrom is not anticipated.*

Similarly claims 26-33, which depend from claim 15 and add significant additional limitations thereto, are not anticipated by Wu et al. and Appellant respectfully requests that the rejections be withdrawn.

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B. CONCLUSION.

For the reasons stated above, claims 15 and 26-33 are not anticipated by Wu et al.; and the Examiner's rejections of claims 15 and 26-33 under 35 U.S.C §102(e) should be withdrawn.

Respectfully submitted,

Karen M. CHEVES et al.

By their Attorney,

Date: Feb 25, 2011



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VIII. CLAIMS APPENDIX

1-14. (canceled)

15. (previously presented) A cutting balloon catheter, comprising:

an elongate catheter shaft;

a balloon coupled to the shaft, the balloon having a first fully inflated configuration and a second non-inflated configuration, wherein the balloon has a plurality of substantially smooth wings formed therein when in the second non-inflated configuration;

a metallic cutting blade for severing or breaking up a lesion adhesively bonded to the balloon throughout the entire use of the cutting balloon catheter, the cutting blade including means for cutting having two intersecting planes which form a cutting edge, including means for gripping thereon, having a longitudinal axis, and having a cross-sectional shape that is substantially triangular in a plane transverse to the longitudinal axis;

wherein the means for cutting and means for gripping are defined by a series of undulations on the cutting blade in the first fully inflated configuration; and

wherein the undulations curve from side-to-side relative to the longitudinal axis in the first fully inflated configuration.

16-25. (canceled)

26. (previously presented) The cutting balloon catheter of claim 15, wherein the wings comprise a plurality of alternating inward and outward radial deflections in the balloon.

27. (previously presented) The cutting balloon catheter of claim 15, wherein the wings are evenly spaced circumferentially around the balloon.

28. (previously presented) The cutting balloon catheter of claim 15, wherein the balloon comprises four wings evenly spaced circumferentially around the balloon.

29. (previously presented) The cutting balloon catheter of claim 15, further comprising a plurality of additional metallic cutting blades adhesively bonded to the balloon and spaced circumferentially between respective pairs of adjacent wings.

30. (previously presented) The cutting balloon catheter of claim 29, wherein the metallic cutting blade and the plurality of additional metallic cutting blades are positioned at an inward-most position of respective pairs of adjacent wings.

31. (previously presented) The cutting balloon catheter of claim 29, wherein the wings fold over and cover the metallic cutting blade and the plurality of additional metallic cutting blades when the balloon is in the second non-inflated configuration.

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32. (previously presented) The cutting balloon catheter of claim 15, wherein the cutting blade includes at least one fully textured surface.

33. (previously presented) The cutting balloon catheter of claim 15, wherein the cutting blade includes at least one partially textured surface.

34. (cancelled)

IX. EVIDENCE APPENDIX

U.S. Pat. App. Pub. No. 2005/0228343 to Kelly

- Presented in Appellant's Remarks in Amendment filed on September 8,
2010.

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X. RELATED PROCEEDINGS APPENDIX

None.



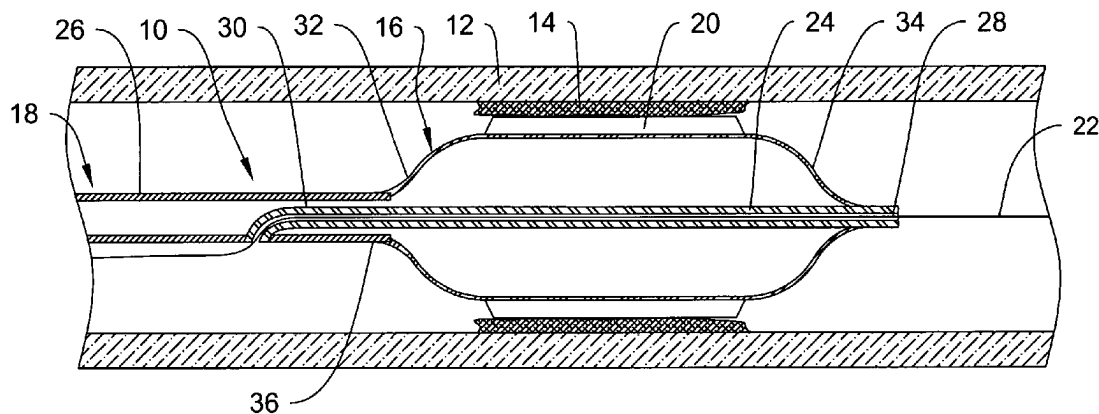
US 20050228343A1

(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0228343 A1****Kelley**(43) **Pub. Date: Oct. 13, 2005**(54) **CUTTING BALLOON CATHETER AND
METHOD FOR BLADE MOUNTING****Publication Classification**(75) Inventor: **Gregory S. Kelley**, San Diego, CA
(US)(51) **Int. Cl.⁷** **A61M 29/00**(52) **U.S. Cl.** **604/96.01; 604/22; 29/428**

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MINNEAPOLIS, MN 55403-2420 (US)(57) **ABSTRACT**

A cutting balloon catheter and methods for making and using the same. The cutting balloon catheter may include a catheter shaft having a balloon coupled thereto. One or more cutting members or blades may be coupled to the balloon. Manufacturing the cutting balloon catheter may include partially submerging or embedding a cutting member within a joining member and attaching the joining member to a balloon. The cutting member may include one or more slots along its base that can interlock with the joining member.

(73) Assignee: **SciMed Life Systems, Inc.**(21) Appl. No.: **10/821,237**(22) Filed: **Apr. 8, 2004**

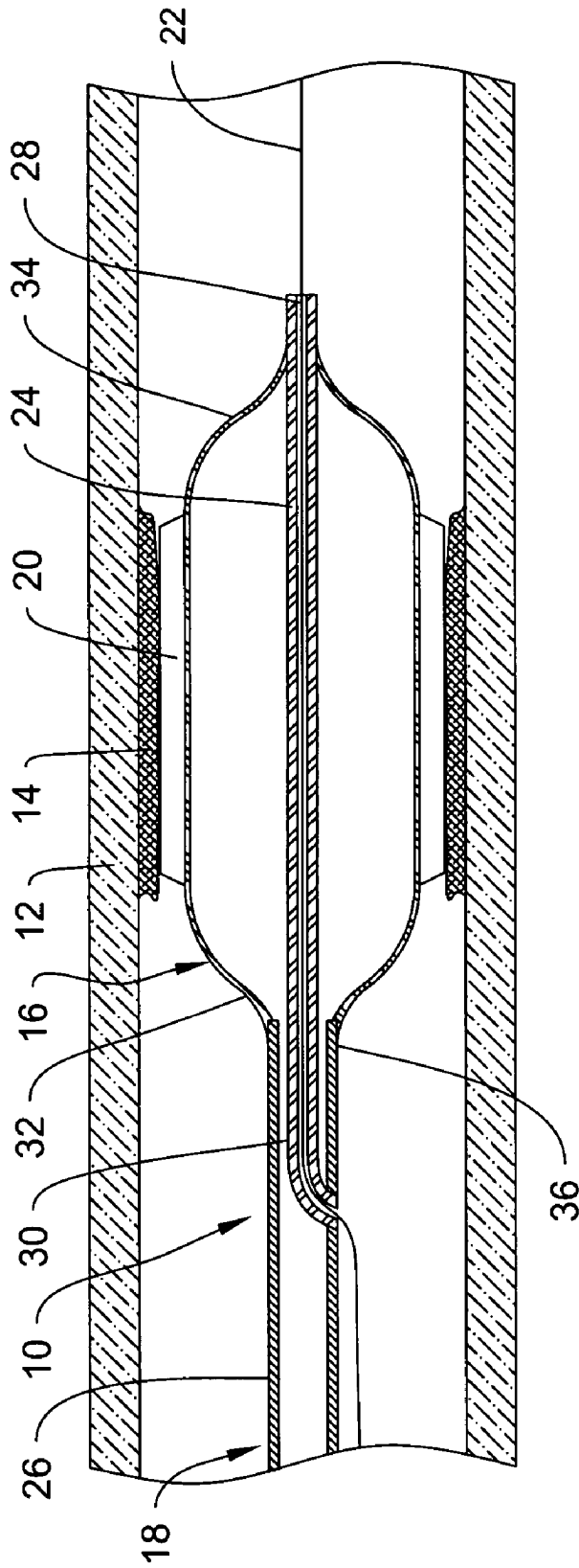


Figure 1

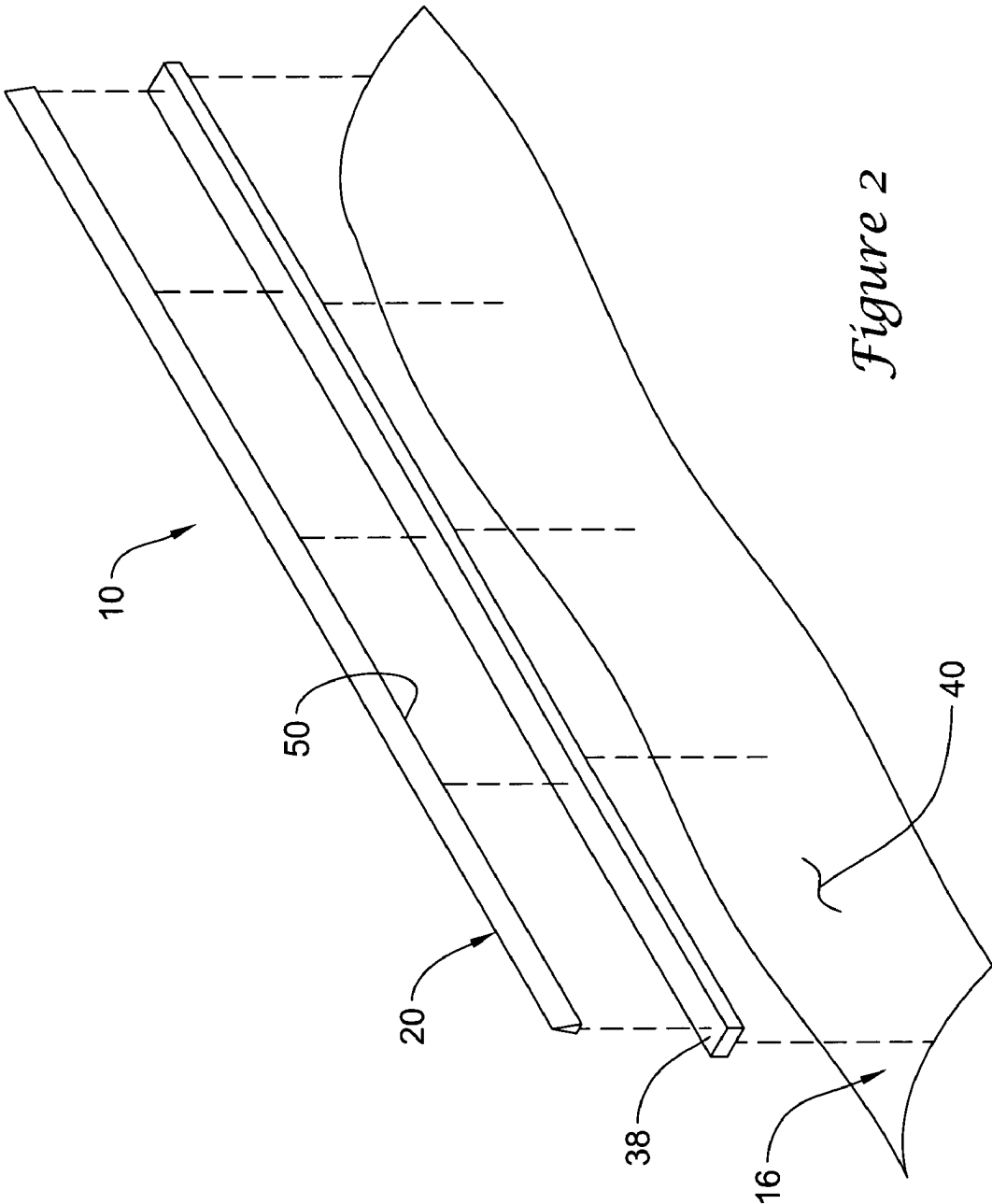


Figure 2

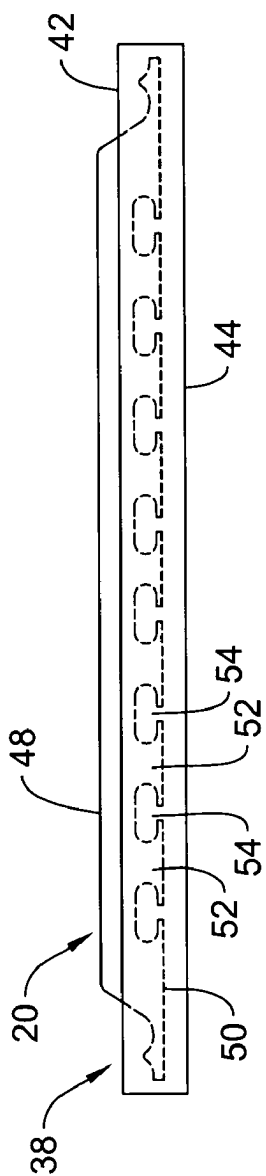


Figure 3

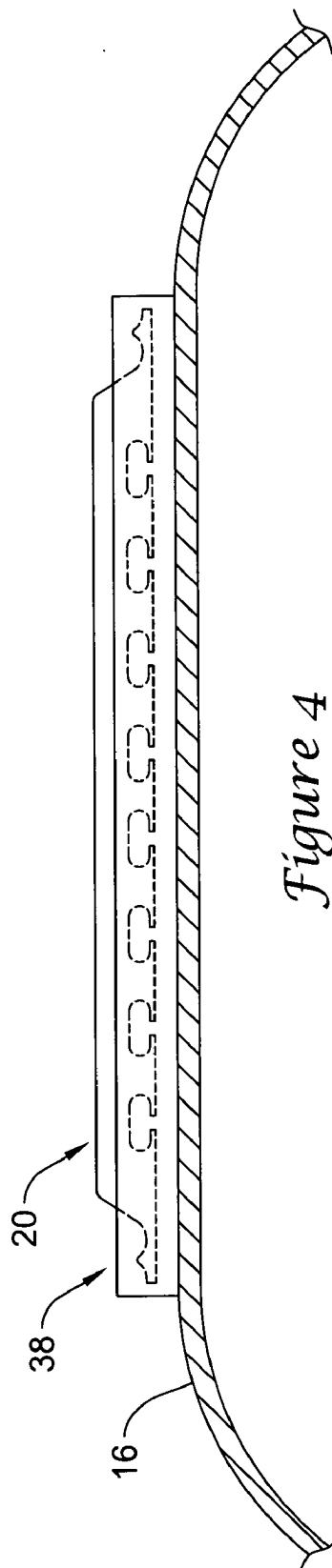


Figure 4

CUTTING BALLOON CATHETER AND METHOD FOR BLADE MOUNTING

FIELD OF THE INVENTION

[0001] The present invention pertains to balloon catheters and methods for making balloon catheters. More particularly, the present invention pertains to angioplasty balloon catheters that include one or more cutting blades coupled to the angioplasty balloon and methods for making cutting balloon catheters.

BACKGROUND

[0002] Heart and vascular disease are major problems in the United States and throughout the world. Conditions such as atherosclerosis result in blood vessels becoming blocked or narrowed. This blockage can result in lack of oxygenation of the heart, which has significant consequences because the heart muscle must be well oxygenated in order to maintain its blood pumping action.

[0003] Occluded, stenotic, or narrowed blood vessels may be treated with a number of relatively non-invasive medical procedures including percutaneous transluminal angioplasty (PTA), percutaneous transluminal coronary angioplasty (PTCA), and atherectomy. Angioplasty techniques typically involve the use of a balloon catheter. The balloon catheter is advanced over a guidewire so that the balloon is positioned adjacent a stenotic lesion. The balloon is then inflated, and the restriction of the vessel is opened.

[0004] One of the major obstacles in treating coronary artery disease and/or treating blocked blood vessels is re-stenosis. Evidence has shown that cutting the stenosis, for example, with an angioplasty balloon equipped with a cutting blade during treatment can reduce incidence of re-stenosis. Additionally, cutting the stenosis may reduce trauma at the treatment site and/or may reduce the trauma to adjacent healthy tissue. Cutting blades may also be beneficial additions to angioplasty procedures when the targeted occlusion is hardened or calcified. It is believed typical angioplasty balloons, alone, may not be able to expand certain of these hardened lesions. Thus, angioplasty balloons equipped with cutting edges have been developed to attempt to enhance angioplasty treatments. There is an ongoing need for improved angioplasty devices, including cutting angioplasty balloons, and improved methods of treating intravascular stenoses and occlusions. In addition, there is an ongoing need for new methods for making cutting balloon catheters.

BRIEF SUMMARY

[0005] The present invention relates to angioplasty balloon catheters. In at least some embodiments, an example balloon catheter may include a catheter shaft having a balloon coupled thereto. One or more cutting members or blades may be coupled to the balloon. A number of manufacturing methods are also disclosed. These methods may include providing a joining member, attaching a cutting blade to the joining member, and attaching the joining member to a balloon. These and other features are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a partial cross-sectional side view of an example cutting balloon catheter disposed in a blood vessel;

[0007] FIG. 2 is a partial perspective view of a cutting member and a joining member for connecting the cutting member to a balloon;

[0008] FIG. 3 is a side view of a cutting member and a joining member; and

[0009] FIG. 4 is a side view of a cutting member, a joining member, and a portion of a balloon.

DETAILED DESCRIPTION

[0010] The following description should be read with reference to the drawings wherein like reference numerals indicate like elements throughout the several views. The detailed description and drawings illustrate example embodiments of the claimed invention.

[0011] FIG. 1 is a partial cross-sectional side view of an example catheter 10 disposed in a blood vessel 12 and positioned adjacent an intravascular lesion 14. Catheter 10 may include a balloon 16 coupled to a catheter shaft 18. One or more cutting members or blades 20 may be coupled to balloon 16. In general, catheter 10 may be advanced over a guidewire 22, through the vasculature, to a target area. Balloon 16 can then be inflated to expand lesion 14, and cutting members 20 may cut lesion 14. The target area may be within any suitable peripheral or cardiac vessel lumen location.

[0012] One aspect of the invention relates to catheters, for example, like catheter 10. Another aspect of the invention relates to methods for making and using catheters, for example, like catheter 10. Some of the methods for making catheters disclosed herein relate to the way cutting members 20 are attached to balloon 16. Attaching cutting members 20 to balloon 16 may be accomplished in a number of ways. For example, a joining member 38 (not shown in FIG. 1, best seen in FIG. 2) may be disposed between cutting members 20 and balloon 16. The method for attaching cutting member 20 may include attaching cutting member 20 to joining member 38 and attaching joining member 38 to balloon 16. In some embodiments, cutting member 20 may be attached to joining member 38 prior to attaching joining member 38 to balloon 16. In other embodiments, the order may be reversed. A more detailed description of some of the methods for coupling cutting members 20 with balloon 16 is provided below.

[0013] Cutting members 20 may be made from any suitable material such as a metal, metal alloy, polymer, metal-polymer composite, and the like, or any other suitable material. For example, cutting member 20 may be made from stainless steel such as 304V, 304L, or 316L stainless steel. In some other embodiments, cutting member 20 is made from an iron-cobalt-nickel alloy such as Aermet®100, which is commercially available from Carpenter Technology Corporation. Some examples of other suitable materials are listed below in relation to balloon 16 and shaft 18. Cutting members 20 may vary in number, position, and arrangement about balloon 16. For example, catheter 10 may include one, two, three, four, five, six, or more cutting members 20 that are disposed at any position along balloon 16 and in a regular, irregular, or any other suitable pattern.

[0014] Balloon 16 may be made from typical angioplasty balloon materials including polymers such as polyethylene terephthalate (PET), polyetherimide (PEI), polyethylene

(PE), etc. Some other examples of suitable polymers, including lubricious polymers, may include polytetrafluoroethylene (PTFE), ethylene tetrafluoroethylene (ETFE), fluorinated ethylene propylene (FEP), polyoxymethylene (POM), polybutylene terephthalate (PBT), polyether block ester, polyurethane, polypropylene (PP), polyvinylchloride (PVC), polyether-ester (for example, a polyether-ester elastomer such as ARNITEL® available from DSM Engineering Plastics), polyester (for example, a polyester elastomer such as HYTREL® available from DuPont), polyamide (for example, DURETHAN® available from Bayer or CRISTAMID® available from Elf Atochem), elastomeric polyamides, block polyamide/ethers, polyether block amide (PEBA, for example, available under the trade name PEBAX®), silicones, Marlex high-density polyethylene, Marlex low-density polyethylene, linear low density polyethylene (for example, REXELL®), polyetheretherketone (PEEK), polyimide (PI), polyphenylene sulfide (PPS), polyphenylene oxide (PPO), polysulfone, nylon, perfluoro-(propyl vinyl ether) (PFA), other suitable materials, or mixtures, combinations, copolymers thereof, polymer/metal composites, and the like. In some embodiments, it may be desirable to use high modulus or generally stiffer materials so as to reduce balloon elongation. The above list of materials includes some examples of higher modulus materials. Some other examples of stiffer materials include polymers blended with liquid crystal polymer (LCP) as well as the materials listed above. For example, the mixture can contain up to about 5% LCP.

[0015] Balloon 16 may be configured so that it includes one or more “wings” or wing-shaped regions when balloon 16 is deflated. These wings may appear as a plurality of alternating inward and outward radial deflections in balloon 16 when balloon 16 is deflated. These wings may be desirable for a number of reasons. For example, by including balloon 16 with wings, balloon 16 may have more predictable and consistent re-folding characteristics. Additionally, the wings may be configured so that cutting members 20 can be positioned at the inward-most positions of the deflated balloon 16. This arrangement allows cutting members 20 to be positioned more closely to shaft 18 when balloon 16 is deflated. Accordingly, cutting members 20 can be moved away from the vessel walls where they might otherwise result in contact and, possibly, damage to healthy tissue during movement of catheter 10 within a body lumen. Additionally, alternating the wings and cutting members 20 as well as positioning cutting members 20 relatively close to shaft 18 may allow the wings to fold over and cover cutting members 20 when balloon 16 is deflated. Again, this feature may reduce the exposure of cutting members 20 to the blood vessel.

[0016] Shaft 18 may be a catheter shaft, similar to typical catheter shafts. For example, shaft 18 may include an inner tubular member 24 and outer tubular member 26. Tubular members 24/26 may be manufactured from a number of different materials. For example, tubular members 24/26 may be made of metals, metal alloys, polymers, metal-polymer composites or any other suitable materials. Some examples of suitable metals and metal alloys include stainless steel, such as 300 series stainless steel (including 304V, 304L, and 316L); 400 series martensitic stainless steel; tool steel; nickel-titanium alloy such as linear-elastic or super-elastic Nitinol, nickel-chromium alloy, nickel-chromium-iron alloy, cobalt alloy, tungsten or tungsten alloys, MP35-N

(having a composition of about 35% Ni, 35% Co, 20% Cr, 9.75% Mo, a maximum 1% Fe, a maximum 1% Ti, a maximum 0.25% C, a maximum 0.15% Mn, and a maximum 0.15% Si), hastelloy, monel 400, inconel 825, or the like; or other suitable material. Some examples of suitable polymers include those described above in relation to balloon 16. Of course, any other polymer or other suitable material including ceramics may be used without departing from the spirit of the invention. The materials used to manufacture inner tubular member 24 may be the same as or be different from the materials used to manufacture outer tubular member 26. Those materials listed herein may also be used for manufacturing other components of catheter 10, including cutting members 20.

[0017] Tubular members 24/26 may be arranged in any appropriate way. For example, in some embodiments inner tubular member 24 can be disposed coaxially within outer tubular member 26. According to these embodiments, inner and outer tubular members 24/26 may or may not be secured to one another along the general longitudinal axis of shaft 18. Alternatively, inner tubular member 24 may follow the inner wall or otherwise be disposed adjacent the inner wall of outer tubular member 26. Again, inner and outer tubular members 24/26 may or may not be secured to one another. For example, inner and outer tubular members 24/26 may be bonded, welded (including tack welding or any other welding technique), or otherwise secured at a bond point. In some embodiments, the bond point may be generally disposed near the distal end of shaft 18. However, one or more bond points may be disposed at any position along shaft 18. The bond may desirably impact, for example, the stability and the ability of tubular members 24/26 to maintain their position relative to one another. In still other embodiments, inner and outer tubular member 24/26 may be adjacent to and substantially parallel to one another so that they are non-overlapping. In these embodiments, shaft 18 may include an outer sheath that is disposed over tubular members 24/26.

[0018] Inner tubular member 24 may include an inner lumen 28. In at least some embodiments, inner lumen 28 is a guidewire lumen. Accordingly, catheter 10 can be advanced over guidewire 22 to the desired location. The guidewire lumen may extend along essentially the entire length of catheter shaft 18 so that catheter 10 resembles traditional “over-the-wire” catheters. Alternatively, the guidewire lumen may extend along only a portion of shaft 18 so that catheter 10 resembles “single-operator-exchange” or “rapid-exchange” catheters. Regardless of which type of catheter is contemplated, catheter 10 may be configured so that balloon 16 is disposed over at least a region of inner lumen 28. In at least some of these embodiments, inner lumen 28 (i.e., the portion of inner lumen 28 that balloon 16 is disposed over) may be substantially coaxial with balloon 16.

[0019] Shaft 18 may also include an inflation lumen 30 that may be used, for example, to transport inflation media to and from balloon 16. The location and position of inflation lumen 30 may vary, depending on the configuration of tubular members 24/26. For example, when outer tubular member 26 is disposed over inner tubular member 24, inflation lumen 30 may be defined within the space between tubular members 24/26. Moreover, depending on the position of inner tubular member 24 within outer tubular mem-

ber 26, the shape of lumen 30 (i.e., the shape adjacent shaft 18) may vary. For example, if inner tubular member 24 is attached to or disposed adjacent to the inside surface of outer tubular member 26, then inflation lumen 30 may be generally half-moon in shape; whereas, if inner tubular member 24 is generally coaxial with outer tubular member 26, then inflation lumen 30 may be generally ring-shaped or annular in shape. It can be appreciated that if outer tubular member 26 is disposed alongside inner tubular member 24, then lumen 30 may be the lumen of outer tubular member 26 or it may be the space defined between the outer surface of tubular members 24/26 and the outer sheath disposed thereover.

[0020] Balloon 16 may be coupled to catheter shaft 18 in any of a number of suitable ways. For example, balloon 16 may be adhesively or thermally bonded to shaft 18. In some embodiments, a proximal waist 32 of balloon 16 may be bonded to shaft 18, for example, at outer tubular member 26, and a distal waist 34 may be bonded to shaft 18, for example, at inner tubular member 24. The exact bonding positions, however, may vary. It can be appreciated that a section of proximal waist 32 may have sections 36 extending therefrom in order for suitable bonding between balloon 16 and outer tubular member 30.

[0021] In addition to some of the structures described above, shaft 18 may also include a number of other structural elements, including those typically associated with catheter shafts. For example, shaft 18 may include a radiopaque marker coupled thereto that may aid a user in determining the location of catheter 10 within the vasculature. In addition, catheter 10 may include a folding spring (not shown) coupled to balloon 16, for example, adjacent proximal waist 32, which may further help in balloon folding and refolding. A description of a suitable folding spring can be found in U.S. Pat. No. 6,425,882, which is incorporated herein by reference.

[0022] An exploded view depicting joining member 38 and how joining member 38 may be disposed between cutting members 20 and balloon 16 is shown in FIG. 2. In general, joining member 38 may be take the form of a strip, band, ribbon, or the like. Joining member 38 may be made from any suitable material such as any of the polymers described herein. For example, joining member 38 may be made from thermoplastic material (i.e., a material whose viscosity changes with the induction of heat), a thermoplastic-like material, a thermoset material, combinations thereof, or the like. Some examples of these and other suitable polymers are listed above. In some embodiments, joining member 38 may be formed from a generally flexible or soft material that allows the interface or connection between cutting member 20 and balloon 16 to be secure while also being, in some embodiments, somewhat elastic or pliable. For example, joining member 38 may be manufactured from a low durometer polyurethane or any other suitable material (including any of the polymers and other materials disclosed herein). Accordingly, cutting member 20 may be securely coupled to balloon 16 while still being able to move laterally about eight degrees or less. Additionally, different portions of cutting member 20 may be able to bend or flex, while other portions remain essentially unchanged. In other embodiments, joining member 38 may be formed from a somewhat harder material.

[0023] In at least some embodiments, joining member 38 can be attached to and disposed between cutting member 20 and balloon 16. For example, joining member 38 can be attached to an outer surface 40 of balloon 16 and to a base 50 of the cutting member 20. The attachment of joining member 38 with cutting member 20 and balloon 16 may be achieved in any appropriate manner, such as by adhesive bonding, casting, thermal bonding, mechanically connecting, welding, brazing, and the like, or in any other suitable way. In some embodiments, attaching joining member 38 with balloon 16 may include bringing joining member 38 into a liquefied, partially liquefied, molten, or partially molten state. According to this embodiment, joining member 38 can be brought into contact with balloon 16 (either while in the liquefied state or just prior to being in the liquefied state), and then become attached to balloon 16 by solidifying. For example, joining member 38 can be heated by directing laser energy onto it prior to bringing joining member 38 into contact with balloon 16. According to this embodiment, the material making up joining member 38 may become molten or partially molten so that it can meld together with balloon 16 upon cooling. Alternatively, joining member 38 and balloon 16 can be brought into contact, and then laser energy can be directed onto joining member 38 so that joining member 38 can liquefy and meld together with balloon 16.

[0024] As stated above, a number of alternative methods may be used for attaching joining member 38 to balloon 16. For example, joining member 38 may be solvated or partially solvated (i.e., by adding an appropriate solvent) so that it is brought into a solvated liquid or liquefied state. Some examples of a suitable solvents may include tetra hydro furan, which is appropriate for solvating joining members 38 made from polyurethane or hexa fluoro iso propanol, which is appropriate for solvating joining members 38 made from nylon. While in the solvated liquid state, joining member 38 can be brought into contact with balloon 16 and the "liquid" joining member 38 can be allowed to solidify. Alternatively, the suitable solvent can be added after joining member 38 and balloon 16 are brought into contact. This attaching process may additionally include completely or partially removing the solvent. In addition, it may be useful to partially or completely re-solvate joining member 38 in order to perform additional method steps such as attaching cutting members 20. After performing these later-described method steps, it may be, again, appropriate to remove the solvent. It should be noted that the attachment means need not be the same for the attachment between cutting member 20 and joining member 38 as the means used to attach balloon 16 and joining member 38.

[0025] The attachment of cutting member 20 with joining member 38 is shown in FIG. 3. In at least some embodiments, joining member 38 can be brought into a liquid or partially liquefied state in any of the manners described above or in any other suitable manner. For example, joining member 38 may be heated so that it melts or partially melts with the use of a laser that directs laser energy onto a portion of joining member 38 such as a top surface 42. Alternatively, joining member 38 may be brought into a solvated or partially solvated state in a manner similar to what is described above.

[0026] With joining member 38 in a partially molten or liquefied state, cutting member 20 can be positioned within

joining member 38. In some embodiments, it may be desirable to partially submerge or embed cutting member 20 within joining member 38. This may be accomplished by passing cutting member 20 through a top surface 42 of joining member 38 until cutting member 20 is positioned at the desired depth. The desired depth of insertion can vary, but generally is epitomized by base 50 of cutting member 20 being somewhat spaced from a bottom surface 44 of joining member 38.

[0027] One advantage of partially submerging cutting member 20 within joining member 38 is that the structure of cutting member 20 allows for a secure, interlocking relationship to be formed. For example, cutting member 20 may include a cutting surface 48 and a series of alternating tabs 52 and holes or openings 54 that are disposed along its base 50. Tabs 52 and openings 54 may be formed in any suitable manner such as with a wire electric discharge milling technique or any other suitable methodology. During the attachment process, the liquefied or partially liquefied joining member 38 can flow into openings 54. Upon solidification, the dispersal of joining member 38 around cutting member 20 can interlock the two structures. This may improve the integrity of the bonding between cutting member 20 with joining member 38. Because joining member 38 will also be bonded with balloon 16 (as shown in FIG. 4), this interlocking relationship can also improve the overall bonding between cutting member 20 with balloon 16. In some embodiments, this interlocking type of bond may be more secure than bonding the various components with adhesives.

[0028] It can be appreciated that the step of attaching joining member 38 to cutting member 20 can occur either before or after (or essentially simultaneous with) the step of attaching joining member 38 to balloon 16. For example, joining member 38 may be solvated in order to facilitate attachment of cutting member 20 thereto, and then be partially de-solvated. The remaining solvated portion of joining member 38 can be utilized to attach the joining member 38 and cutting member 20 subassembly to balloon 16. Once the subassembly is attached, the remaining solvent can be removed.

[0029] Collectively, the above discussion elucidates a number of methods for manufacturing catheter 10. For example, one step may include attachment of cutting members 20 with joining member 38 in any of the manners described above. Another step may include attachment of joining member 38 with balloon 16 in any of the manner described above. This step may occur either before or after the step of attaching cutting member 20 with joining member 38. These two attachment steps may further include heating (e.g., with the use of a laser), adding and/or removing a solvent, or any other suitable "liquefying" step as described above.

[0030] It should be understood that this disclosure is, in many respects, only illustrative. Changes may be made in details, particularly in matters of shape, size, and arrangement of steps without exceeding the scope of the invention. The invention's scope is, of course, defined in the language in which the appended claims are expressed.

What is claimed is:

1. A method for manufacturing a cutting balloon catheter, comprising the steps of:

providing a strip of polymeric material;

providing a cutting member, the cutting member including a top cutting portion and a slotted base portion having a plurality of slots;

liquefying at least a portion of the strip;

disposing the cutting member adjacent the strip and allowing the liquefied portion of the strip to flow into the slots; and

attaching the strip to a balloon.

2. The method of claim 1, wherein the step of liquefying at least a portion of the strip includes heating the strip.

3. The method of claim 2, wherein heating the strip includes heating the strip with a laser.

4. The method of claim 1, wherein the step of liquefying at least a portion of the strip includes melting the strip.

5. The method of claim 1, wherein the step of liquefying at least a portion of the strip includes liquefying the strip with a solvent.

6. The method of claim 5, further comprising the step of removing the solvent.

7. The method of claim 1, wherein the step of disposing the cutting member adjacent the strip and allowing the liquefied portion of the strip to flow into the slots includes submerging the cutting member in the strip.

8. The method of claim 7, wherein the step of submerging the cutting member in the strip includes submerging the slots of the cutting member in the strip.

9. The method of claim 7, wherein the step of submerging the slots of the cutting member in the strip interlocks the strip with the cutting member.

10. The method of claim 1, wherein the step of attaching the strip to a balloon includes heating the strip.

11. The method of claim 1, wherein the step of attaching the strip to a balloon includes at least partially solvating the strip with a solvent.

12. The method of claim 11, further comprising the step of removing the solvent.

13. The method of claim 1, further comprising the step of cooling the liquefied portion of the strip.

14. The method of claim 1, further comprising the step of disposing a second cutting member adjacent the strip.

15. The method of claim 1, wherein the step of disposing the cutting member adjacent the strip and allowing the liquefied portion of the strip to flow into the slots precedes the step of attaching the strip to a balloon.

16. The method of claim 1, wherein the step of disposing the cutting member adjacent the strip and allowing the liquefied portion of the strip to flow into the slots follows the step of attaching the strip to a balloon.

17. A method for manufacturing a cutting balloon catheter, comprising the steps of:

providing a joining member;

providing a cutting blade, the cutting blade having a cutting surface and an interlocking surface;

softening the joining member;

positioning the cutting blade adjacent the joining member so that the interlocking surface is submerged within the joining member;

solidifying the joining member so that the cutting blade and the joining member are secured to one another; and

attaching the joining member and the cutting blade to an angioplasty balloon.

18. The method of claim 17, wherein the step of softening the joining member includes heating the strip.

19. The method of claim 18, wherein heating the joining member includes heating the joining member with a laser.

20. The method of claim 18, wherein heating the joining member includes melting the joining member.

21. The method of claim 17, wherein the step of softening the joining member includes at least partially solvating the joining member with a solvent.

22. The method of claim 17, wherein the step of attaching the joining member and the cutting blade to an angioplasty balloon includes heating the joining member.

23. The method of claim 22, wherein heating includes heating the joining member with a laser.

24. The method of claim 17, wherein the step of attaching the joining member and the cutting blade to an angioplasty balloon includes at least partially solvating the joining member with a solvent.

25. The method of claim 17, further comprising the step of disposing a second cutting blade adjacent the joining member.

26. A cutting balloon catheter, comprising:

an elongate catheter shaft;

a balloon coupled to the catheter shaft;

a polymeric joining member attached to the balloon; and

a cutting members coupled to the joining member, the cutting member including a cutting surface and a slotted base, the slotted base being submerged within the joining member.

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